2023 Annual AMS Meeting,
Denver, CO, USA & Online
January 8-12, 2023

Joint 25th Conference on Atmospheric Chemistry & 36th Conference on Climate Variability and Change

Upper Tropospheric and Stratospheric Processes

Assessment of the 10-year ozone profile record derived from Suomi NPP OMPS-LP

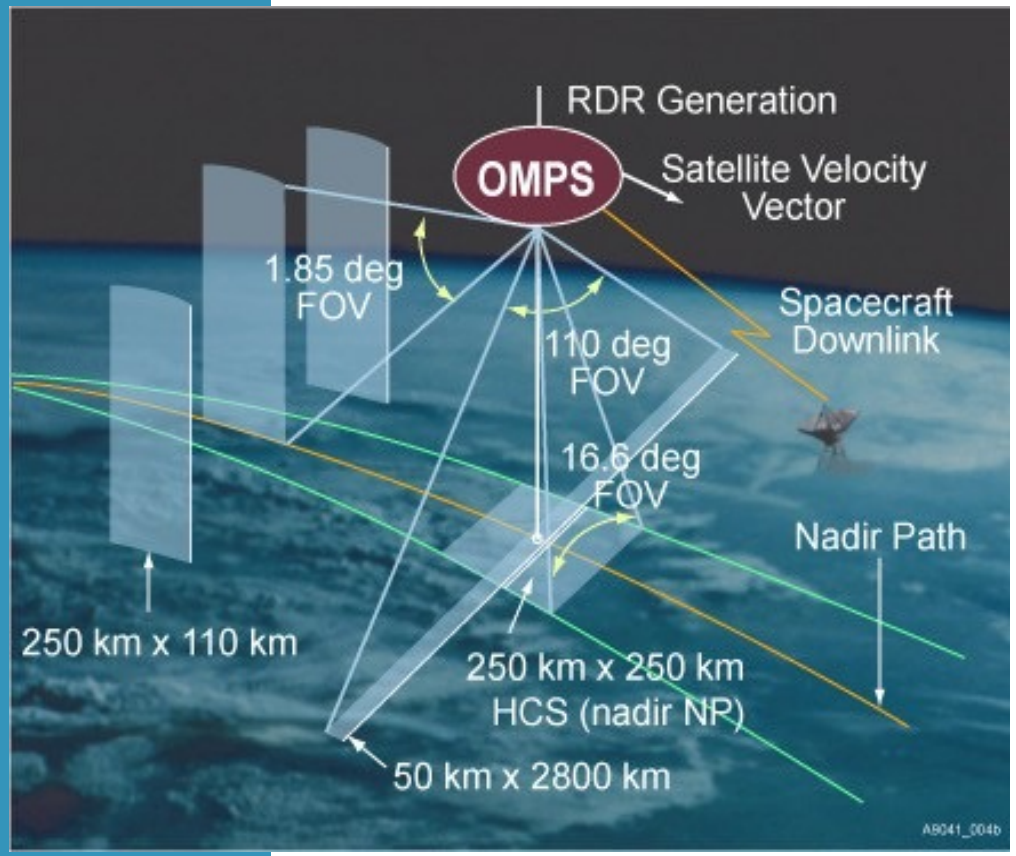
Natalya Kramarova[1], Philippe Xu[2], Jungbin Mok[3], P.K. Bhartia[1,*], Glen Jaross[1], Carlo Arosio[4], Gordon Labow[3], Stacey Frith[3], Jerald Ziemke[5], Sean Davis[6], and Yue Jia[6]

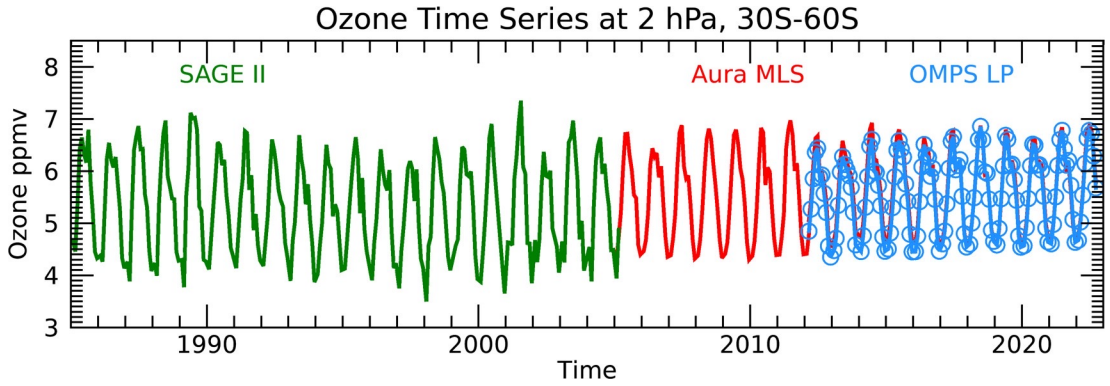
1-NASA GSFC, Greenbelt, MD; 2- SAIC, Greenbelt, MD; 3- SSAI, Greenbelt, MD; 4-University of Bremen; 5-Morgan State University, Baltimore, MD; 6-NOAA CSL, Boulder, CO; * - Emeritus

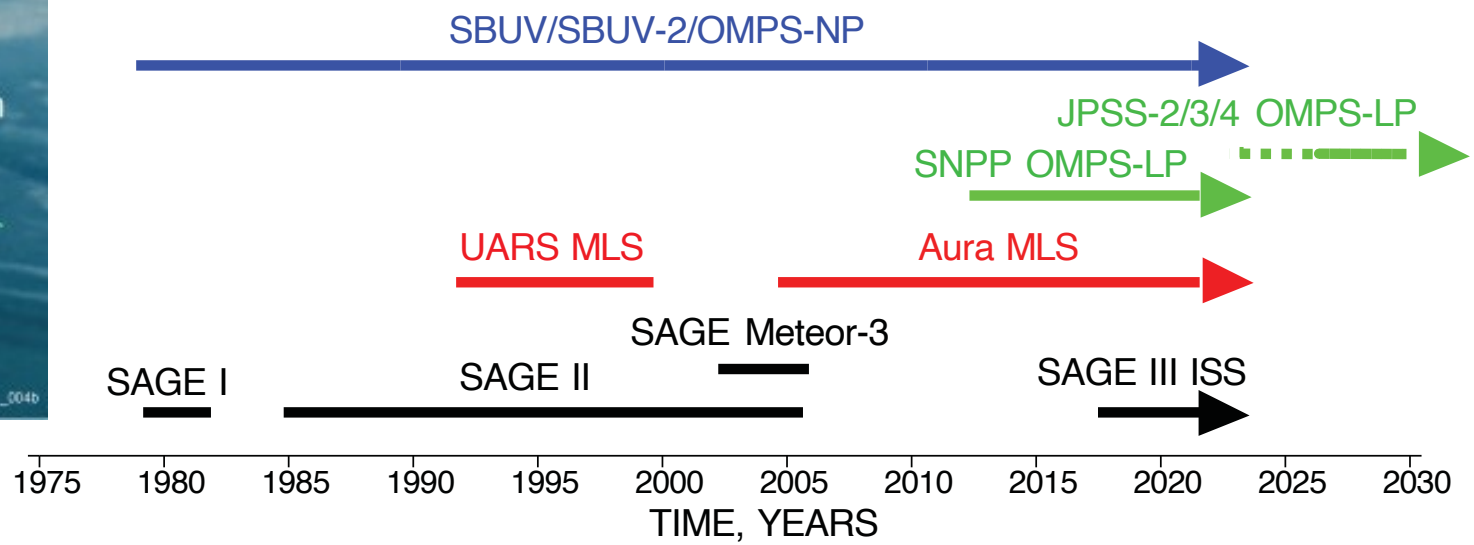
GODDARD EARTH SCIENCES

Natalya.a.Kramarova@nasa.gov

Satellite Ozone Profile Measurements







GODDARD EARTH SCIENCES

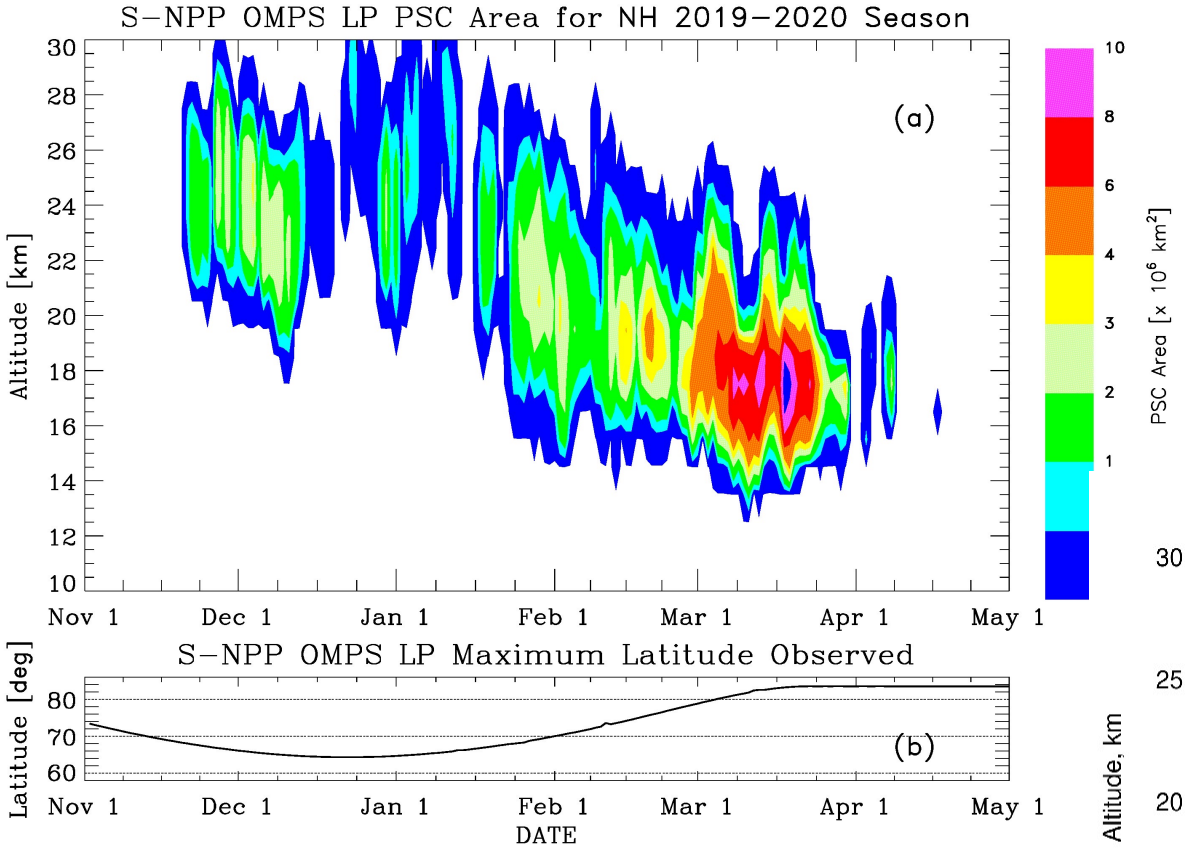
Natalya.a.Kramarova@nasa.gov

JPSS-2 (NOAA-21) successfully lifted off from Vandenberg Space Force Base on November 10, 2022 at 1:49 a.m.

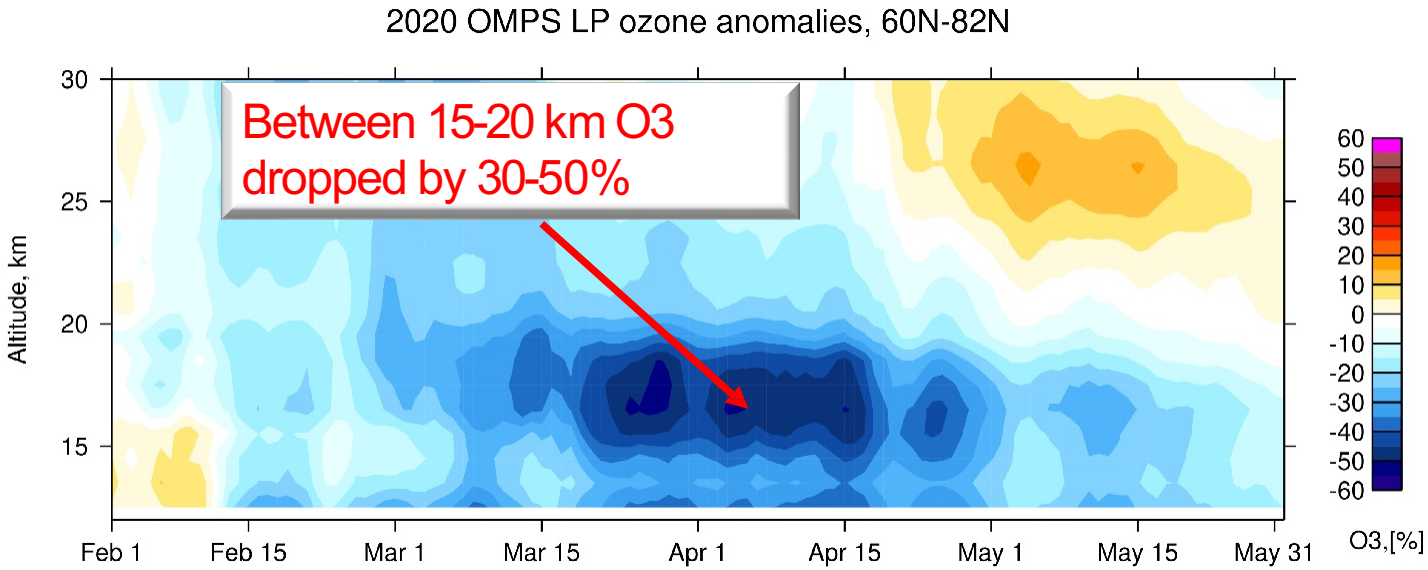
GODDARD EARTH SCIENCES

Natalya.a.Kramarova@nasa.gov

Polar Ozone Monitoring with OMPS



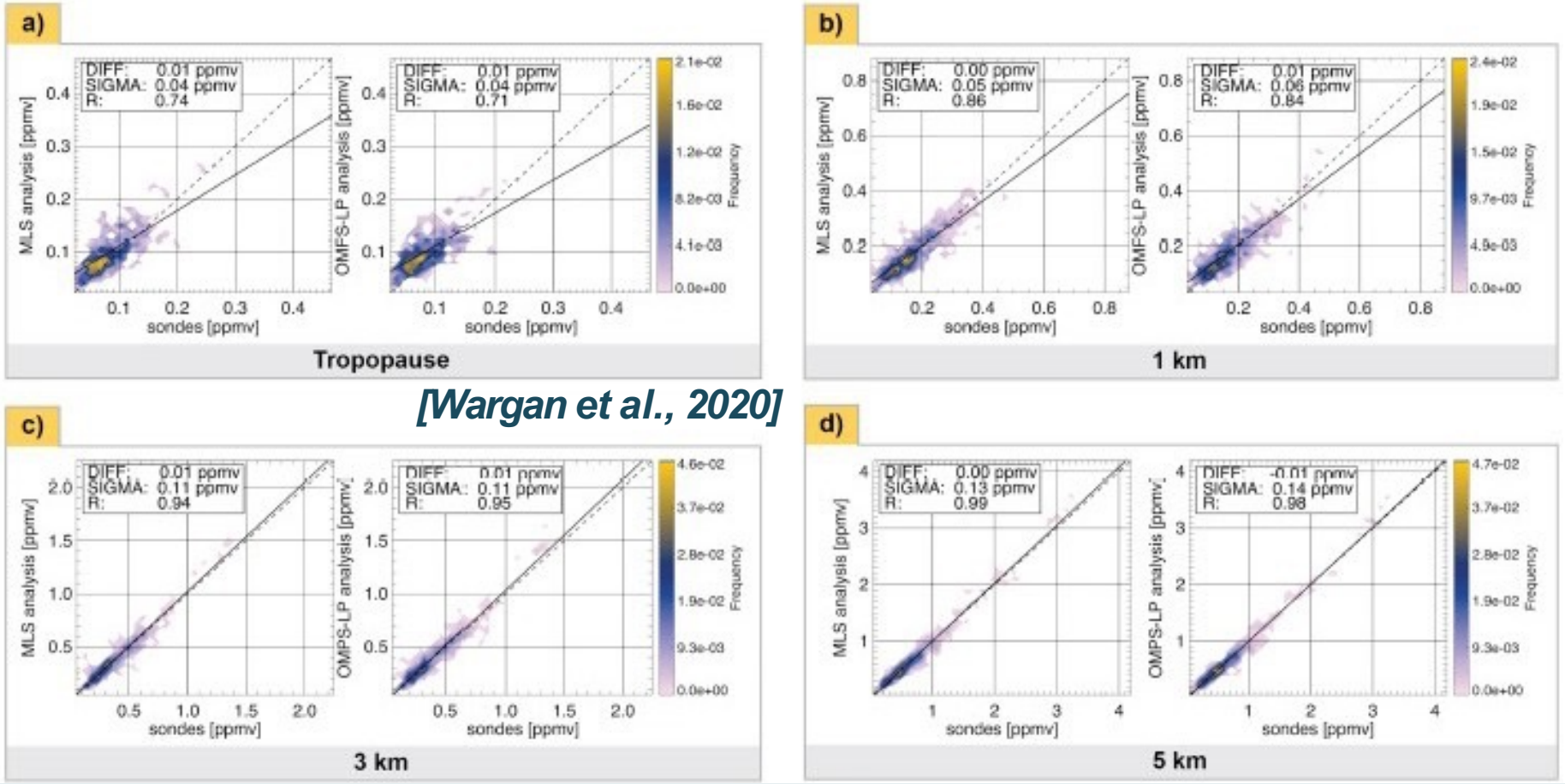
- **Feb-Mar 2020: Lack of planetary wave forcing → stratospheric T below average;**
- **Cold temperatures → increased volume of PSCs over the Arctic;**
- **The Arctic ozone depletion in March 2020 was the worst since 1979.**



[DeLand et al., GRL, 2020]

Natalya.a.Kramarova@nasa.gov

Assimilation of OMPS LP ozone profiles



[Wargan et al., 2020]

- ✓ MLS and OMPS-LP assimilation experiments are in good agreement with independent data and with each other
- ✓ However, further work is needed to reduce a long-term spurious drift in OMPS-LP data

GODDARD EARTH SCIENCES

Natalya.a.Kramarova@nasa.gov

OMPS LP Version 2.6

Level 1	Level 2
Altitude registration: • Static correction update (1.58 km or +200 m); • Remove the second 100m step in Sep. 2014; • Simplified intra-orbital correction (~ 650 m);	**Update O_3 and NO_2 absorption cross sections and climatologies:** • Brion-Dumont-Mallicet (BDM) in UV (290-355 nm); • Serdyuchenko-Gorshelev (SG) in VIS (500-700 nm); • Update O_3 and NO_2 climatological profiles;
Update Stray Light correction: • Slit image increased by a factor of 1.5 for VIS; • 12% increase in the tails for PSF for OOR;	**Combine UV and VIS radiances to retrieve a single O_3 profile;**
Static radiometric calibrations updates: • Smoothed albedo pre-launch; • Goniometric Day-1 + seasonal component; • Wavelength scale Day 1 assignment	**Increase number of wavelengths (6 UV pairs and 1 VIS triplet);**
	Dynamical vertical range for each pair/triplet contribution (based on max sensitivity to O_3);
	Implement Tikhanov regularization to vertically smooth retrieved profiles;
Wavelength-shift correction (time-dependent);	**Update convergence criteria and quality filters;**
Radiometric calibration drift;	**Switch to gamma-function aerosol size distribution;**

GODDARD EARTH SCIENCES

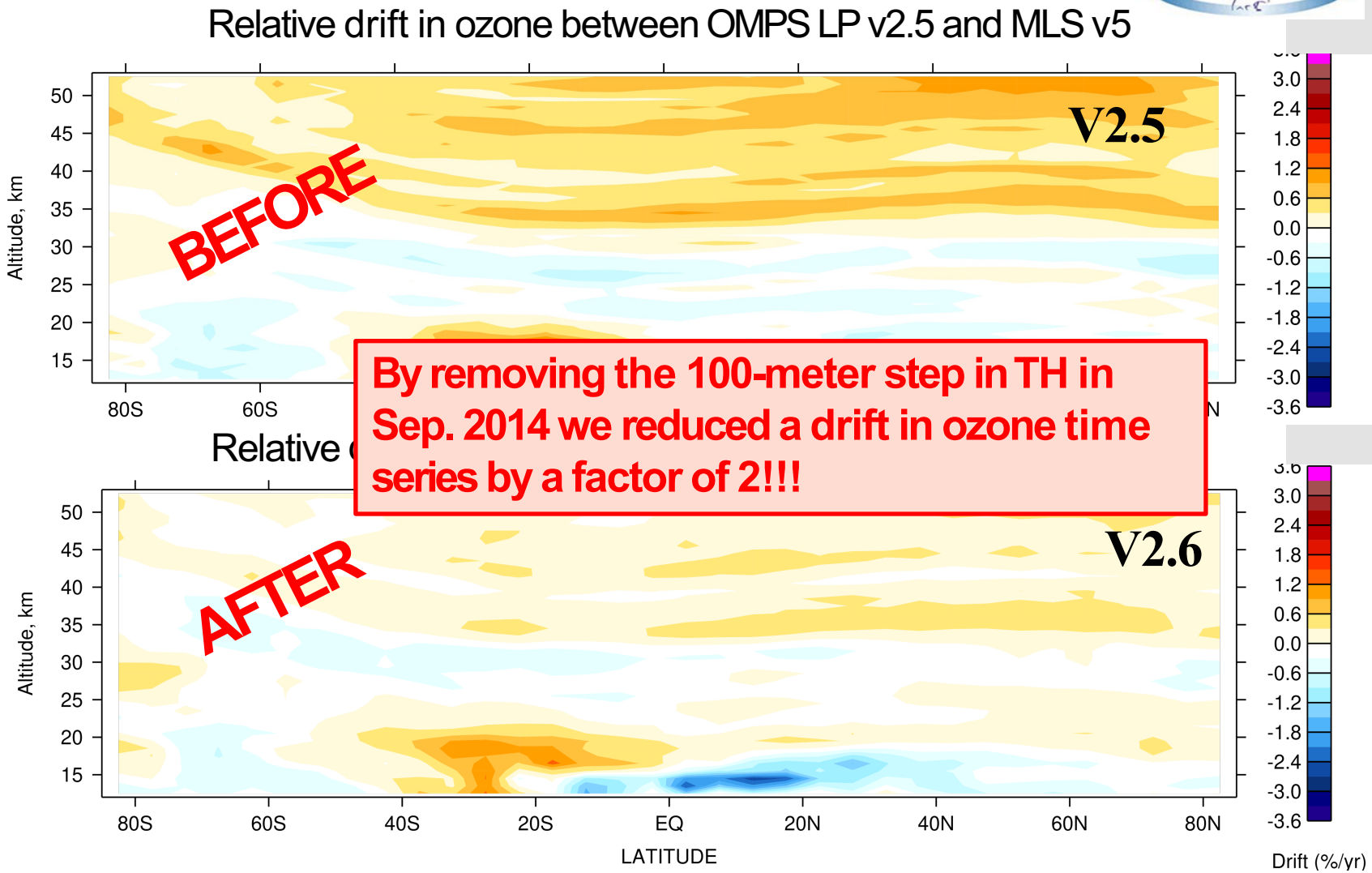
Natalya.a.Kramarova@nasa.gov

Drift in OMPS LP Ozone

Uncertainties in the altitude registration are the main source of errors in the limb scattering technique (200 m ➔ 5% error in O_3).

Drift patterns in v2.5 LP O_3 are consistent with a drift in altitude registration

Preliminary results demonstrate a factor of 2 reduction in relative drifts in v2.6.



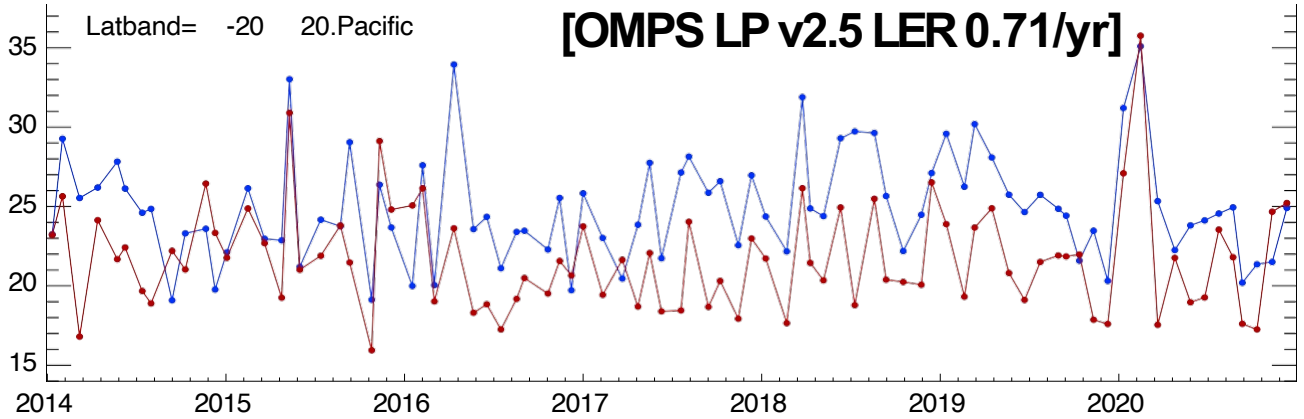
Natalya.a.Kramarova@nasa.gov

Evaluation of OMPS LP altitude registration using OMPS nadir

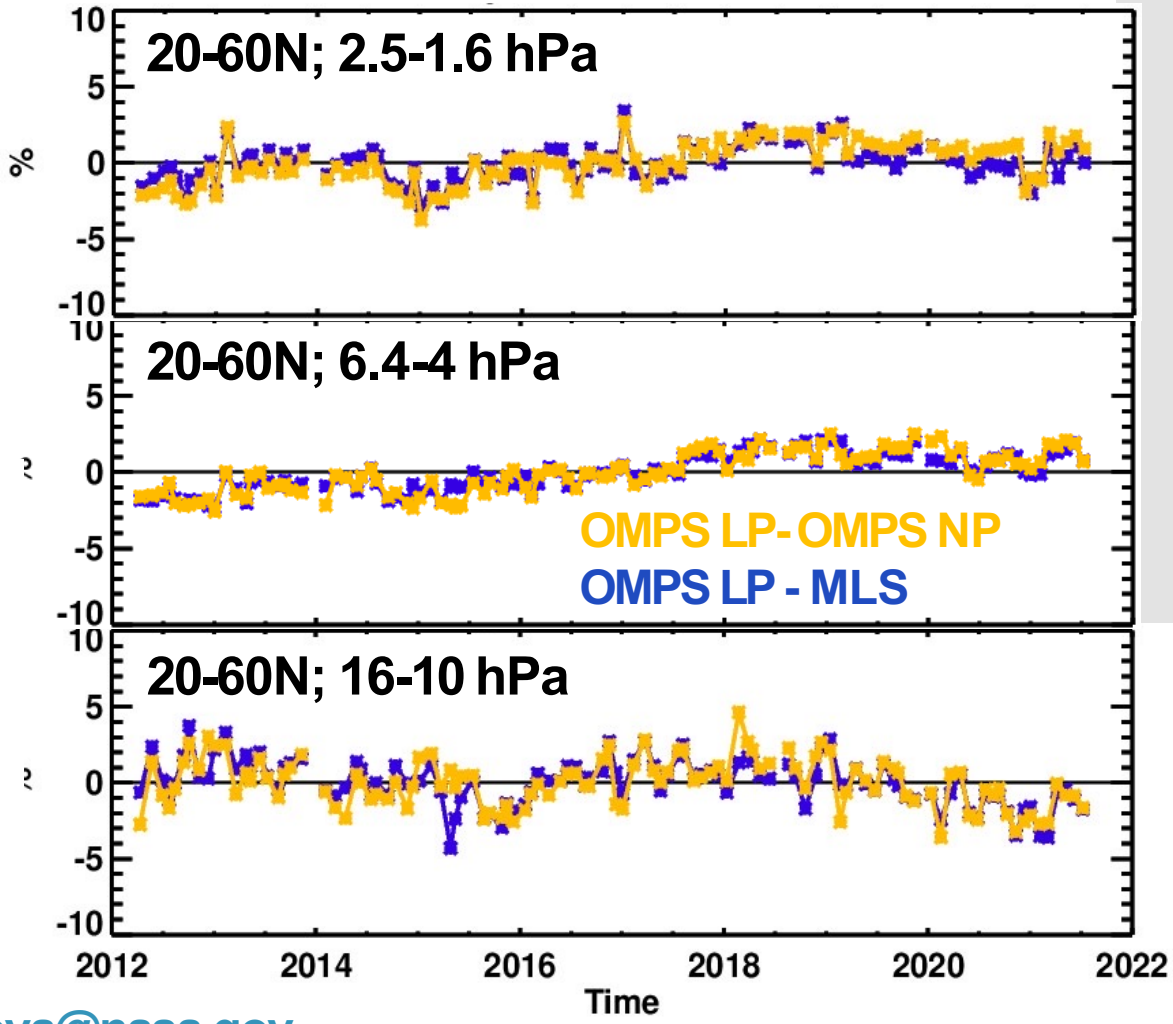
We use reflectivity and ozone profiles derived from OMPS nadir to evaluate the accuracy of the LP altitude registration.

Reflectivity

OMPS NM LER -0.09/yr
OMPS LP v2.6 LER 0.25/yr
[OMPS LP v2.5 LER 0.71/yr]



Ozone de-seasonalized differences in (%)

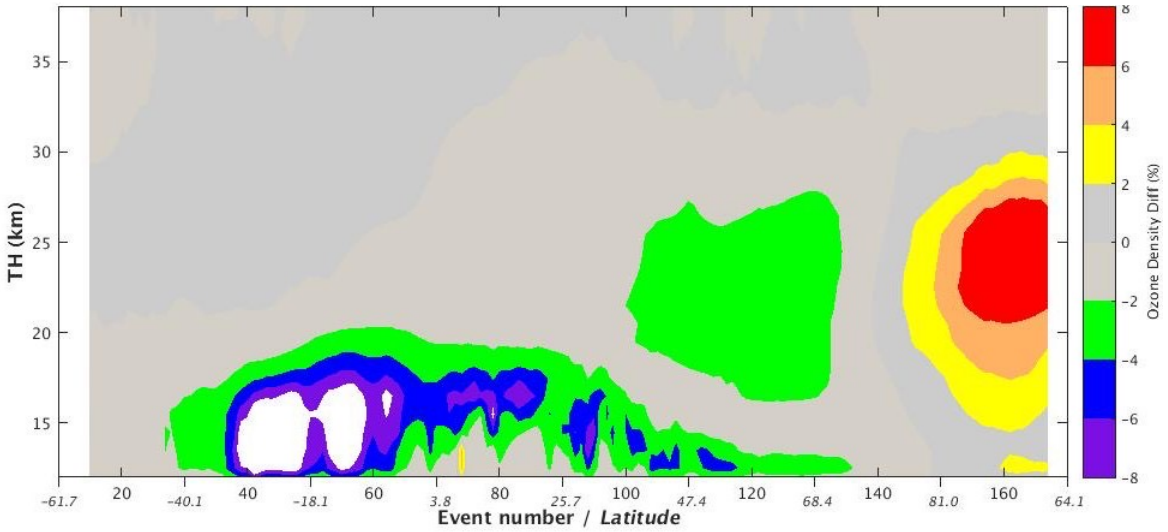


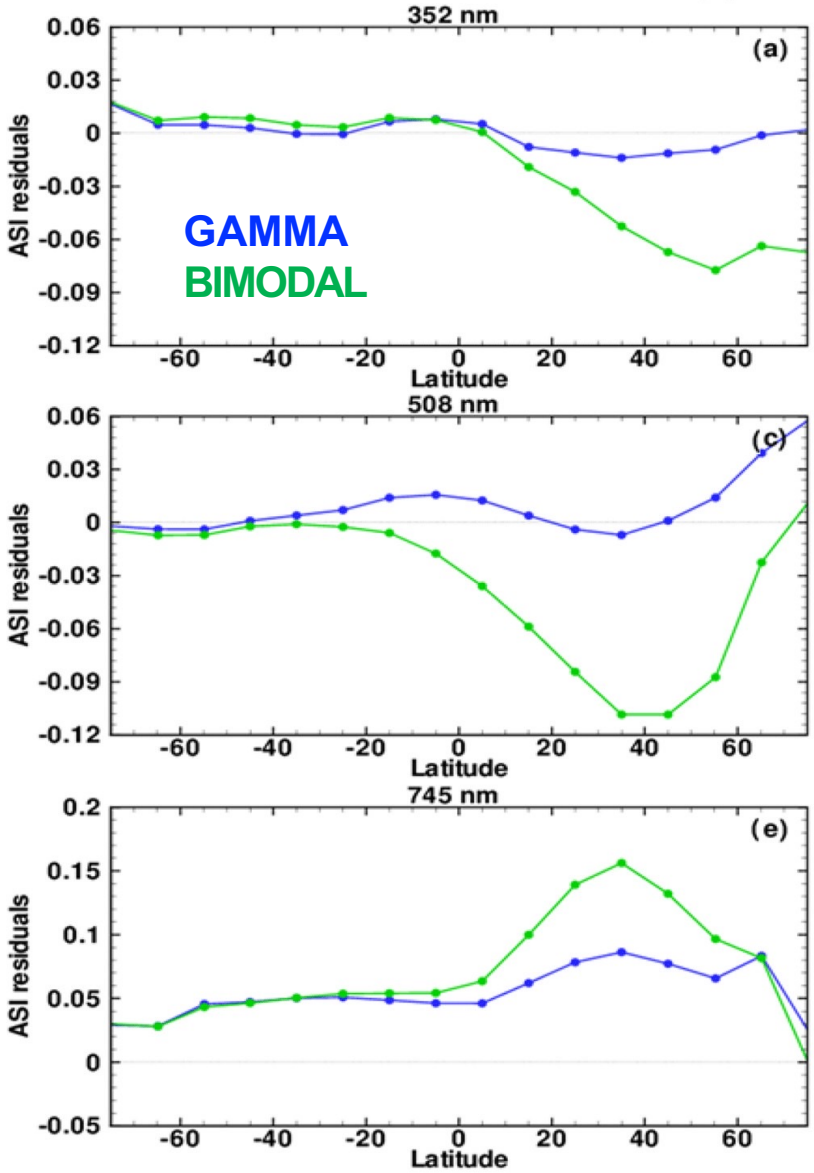
Natalya.a.Kramarova@nasa.gov

Aerosol correction

In v2.5 we assumed the bimodal lognormal particle size distribution (PSD) which we replaced with the gamma function PSD in v2.6.

O3 differences, (Gamma-Bimodal)





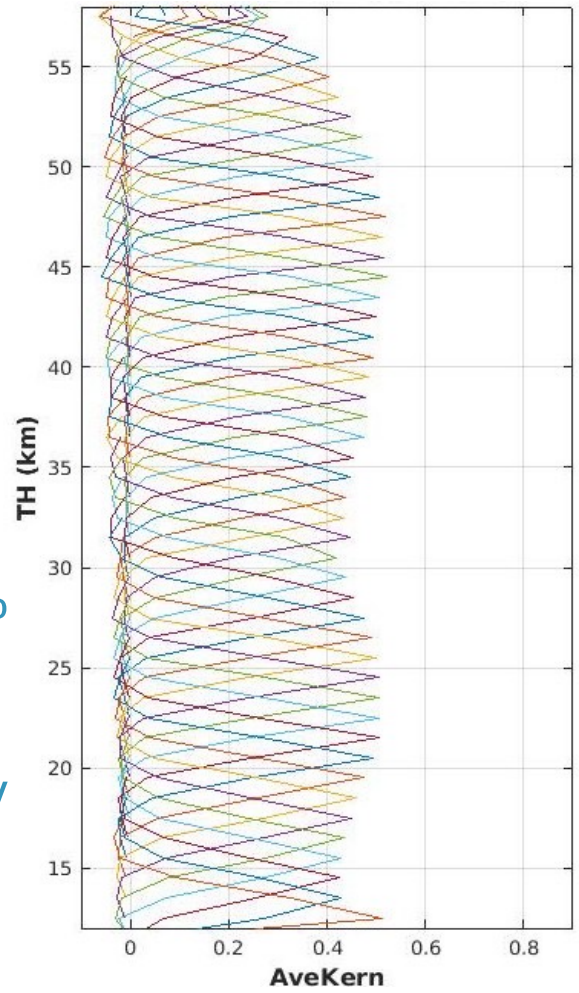
Natalya.a.Kramarova@nasa.gov

Algorithmic updates

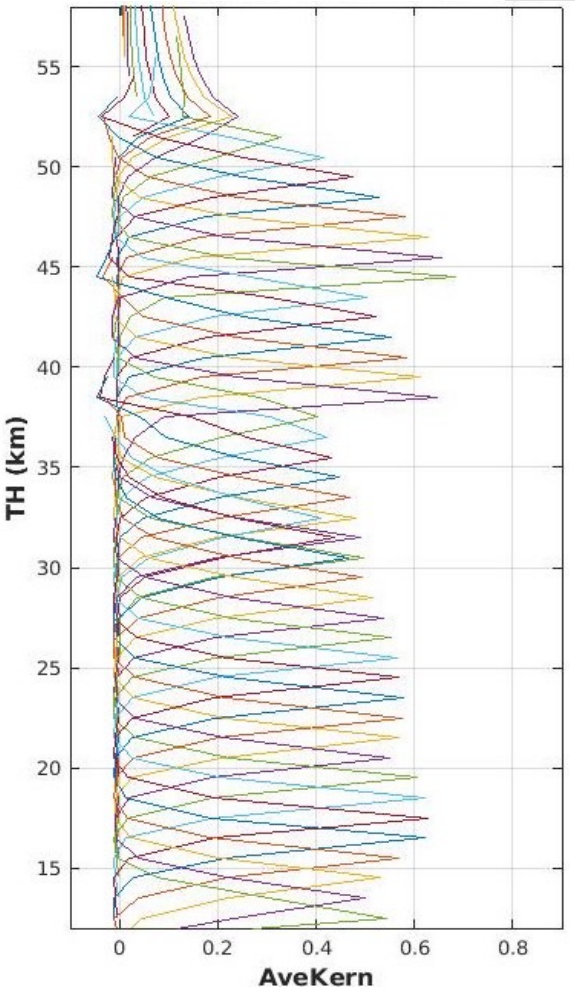
Key changes include:

- Merged UV and VIS → combined O_3 profile;
- Increased number of UV pairs with dynamically controlled contributions;
- Replaced Optimal Estimation with Tikhanov's regularization algorithm.
  - The averaging kernels have consistent widths in the stratosphere leading to a vertical resolution of ~ 2 km
  - The estimated precision reduced to 3-4% between 20 and 52 km (compared to 6-8% in V2.5).
  - Updated convergence criteria and quality flags for data screening.

Averaging Kernels, v2.6

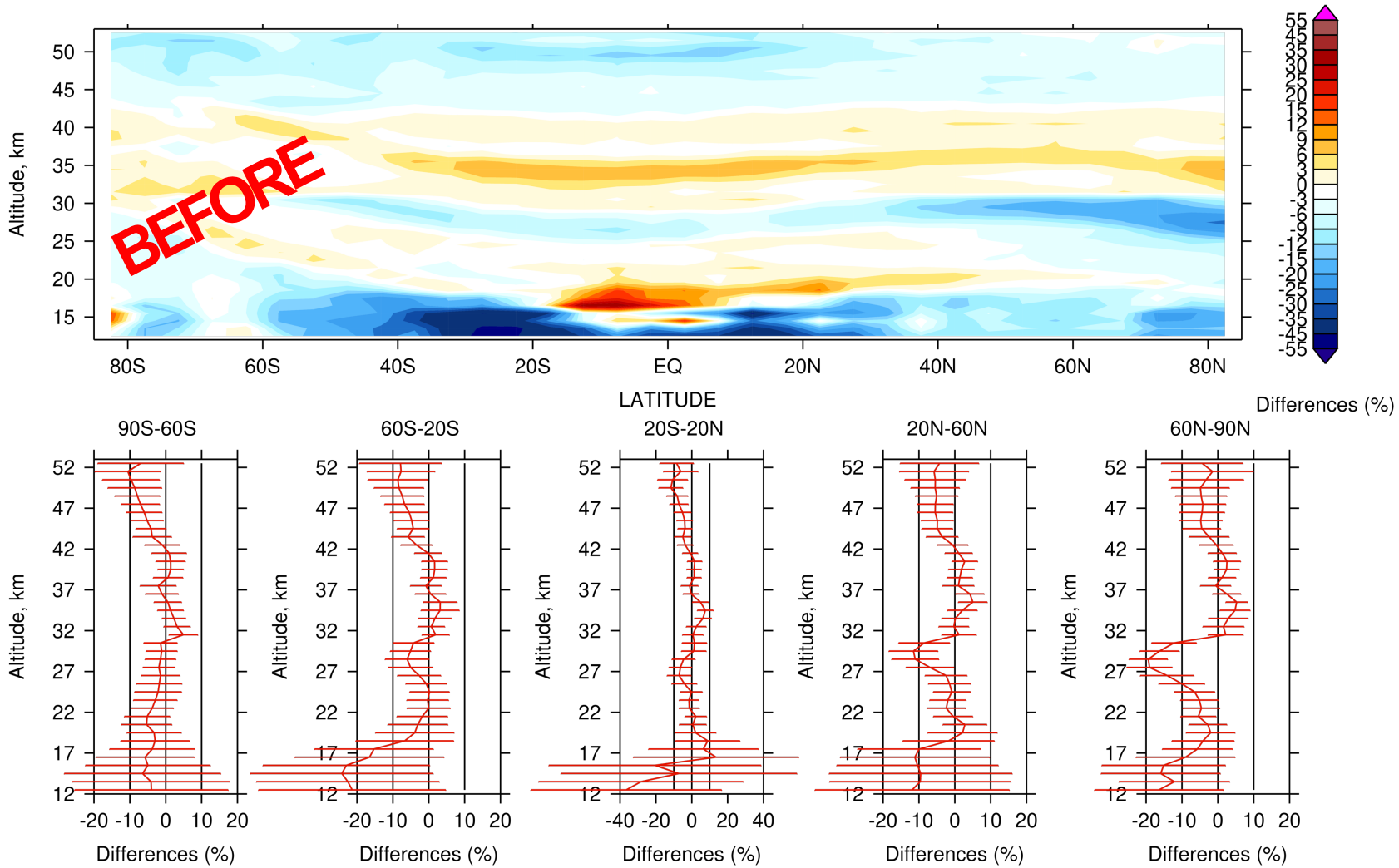


Averaging Kernels, v2.5



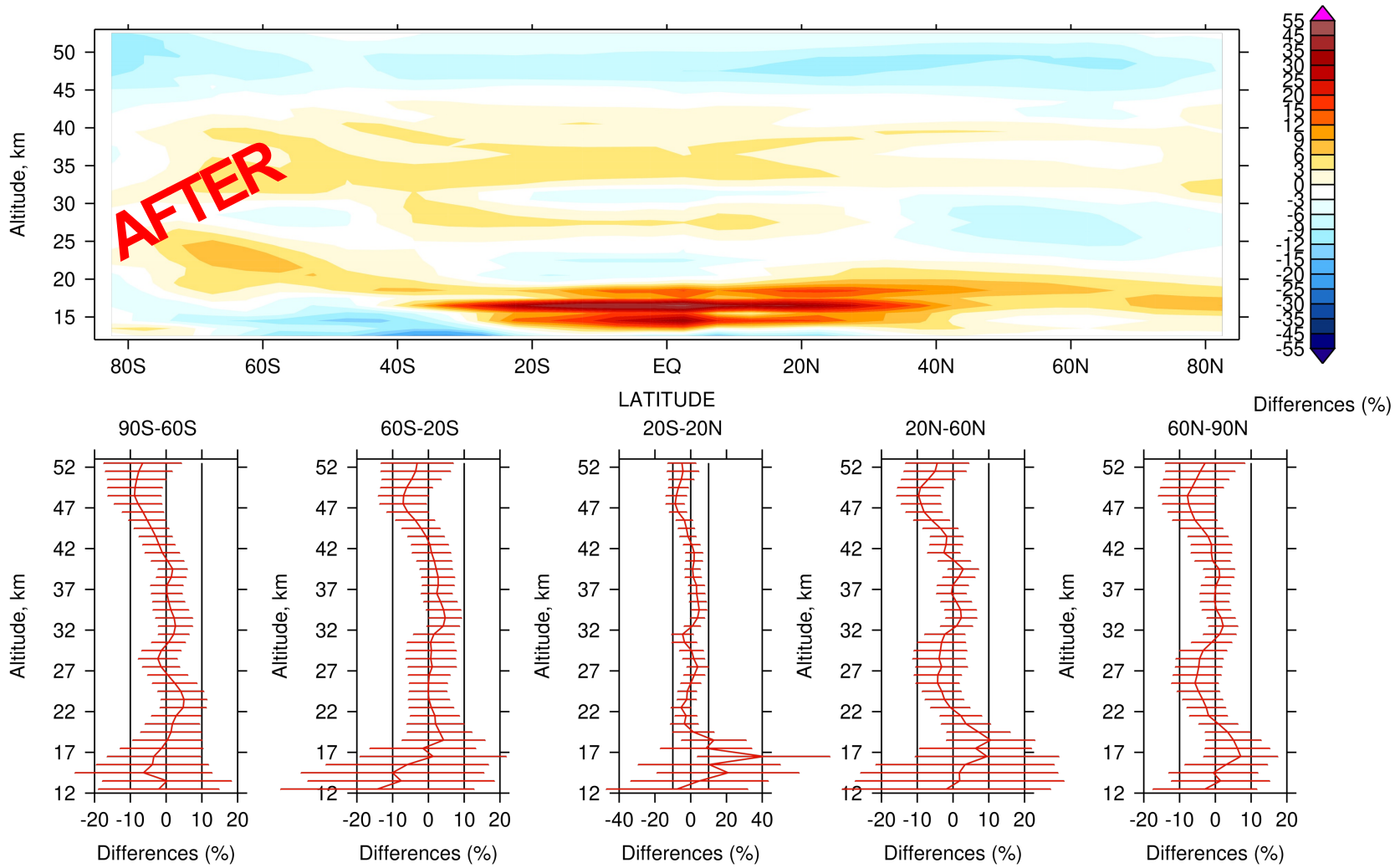
Natalya.a.Kramarova@nasa.gov

Mean differences OMPS LP v2.5 and MLS v5



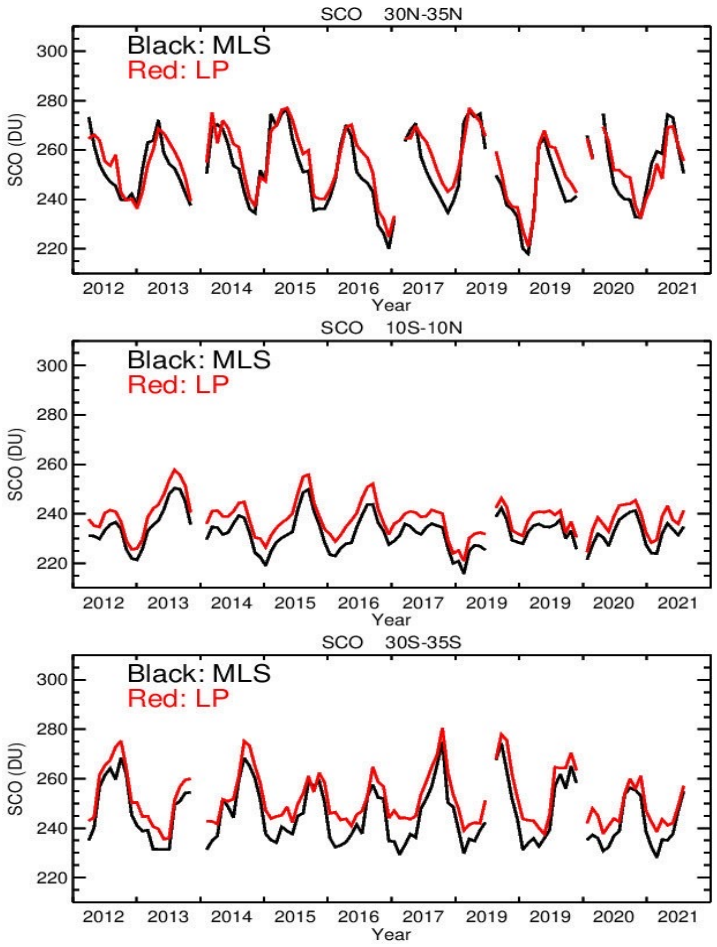
Natalya.a.Kramarova@nasa.gov

Mean differences OMPS LP v2.6 and MLS v5



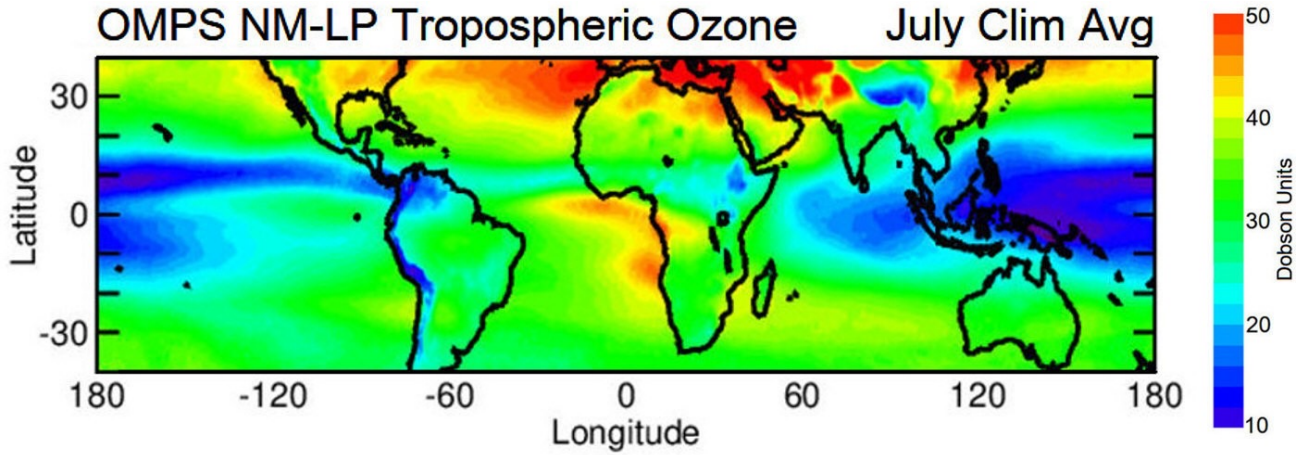
Natalya.a.Kramarova@nasa.gov

Tropospheric Ozone from OMPS Limb and Nadir



For daily tropospheric ozone maps, stratospheric ozone columns (SCO) from LP are highly consistent with MLS

However, the current 12.5 km low altitude cutoff for LP ozone profiles limits global coverage to about ±40° latitudes



Natalya.a.Kramarova@nasa.gov

Summary

- LP retrievals agree well with the correlative satellite observations in characterizing vertical, spatial and temporal ozone distribution.
- The LP ozone measurements provide:
  a) dense coverage of sunlit portion of the Earth;
  b) fine vertical resolution (~ 2 km);
  c) continuation with the 3 follow-up JPSS missions.

Key Improvements in v2.6 include:

✓ Remove the drift in altitude registration resulted in a substantial reduction in relative drifts against other measurements (e.g. MLS).
✓ Smoother transition between UV and VIS due to merging of UV and VIS measurements in the retrieval algorithm.
✓ Consistent sensitivity and vertical resolution from lower stratosphere to lower mesosphere.
✓ Improved aerosol correction
✓ Updated, traceable cross-sections and climatologies for O_3 and NO_2.
✓ Robust set of quality parameters to filter data.

GODDARD EARTH SCIENCES

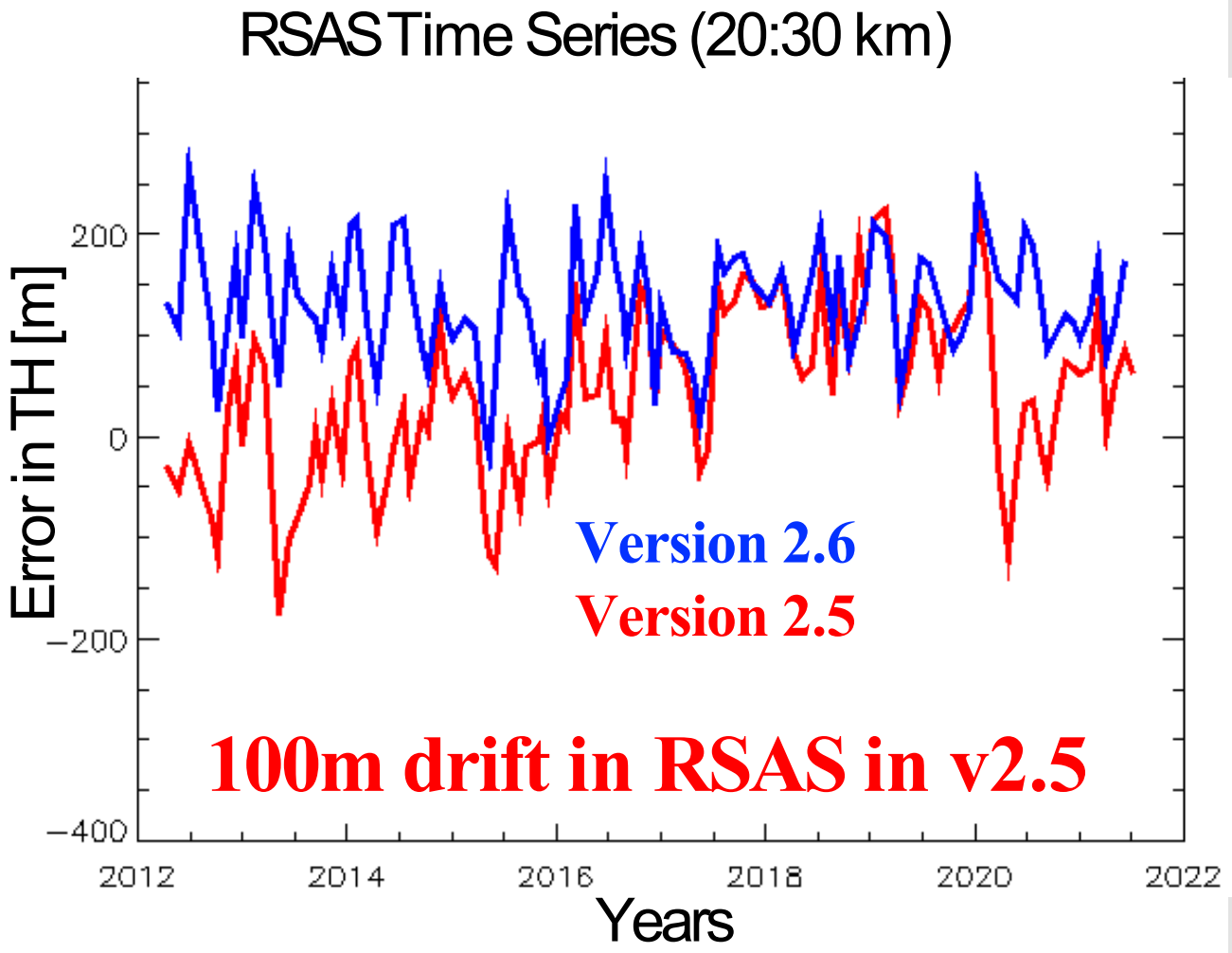
Natalya.a.Kramarova@nasa.gov

Back-up

Natalya.a.Kramarova@nasa.gov

OMPS LP Altitude Registration

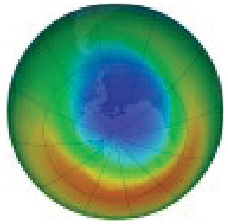
- Uncertainties in the altitude registration are the main source of errors in the limb scattering technique (200 m ➔ 5% error in O_3).
- Preliminary analysis of v2.6 data shows no significant drift in the center slit.
- Radiometric calibrations, improvements in forward model calculations and updated aerosol PSD led to improvements in RSAS time series in v2.6.



Natalya.a.Kramarova@nasa.gov

Evaluation of OMPS LP ozone profiles

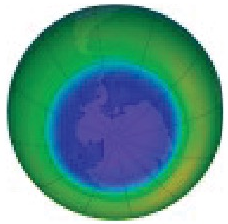
September 2019

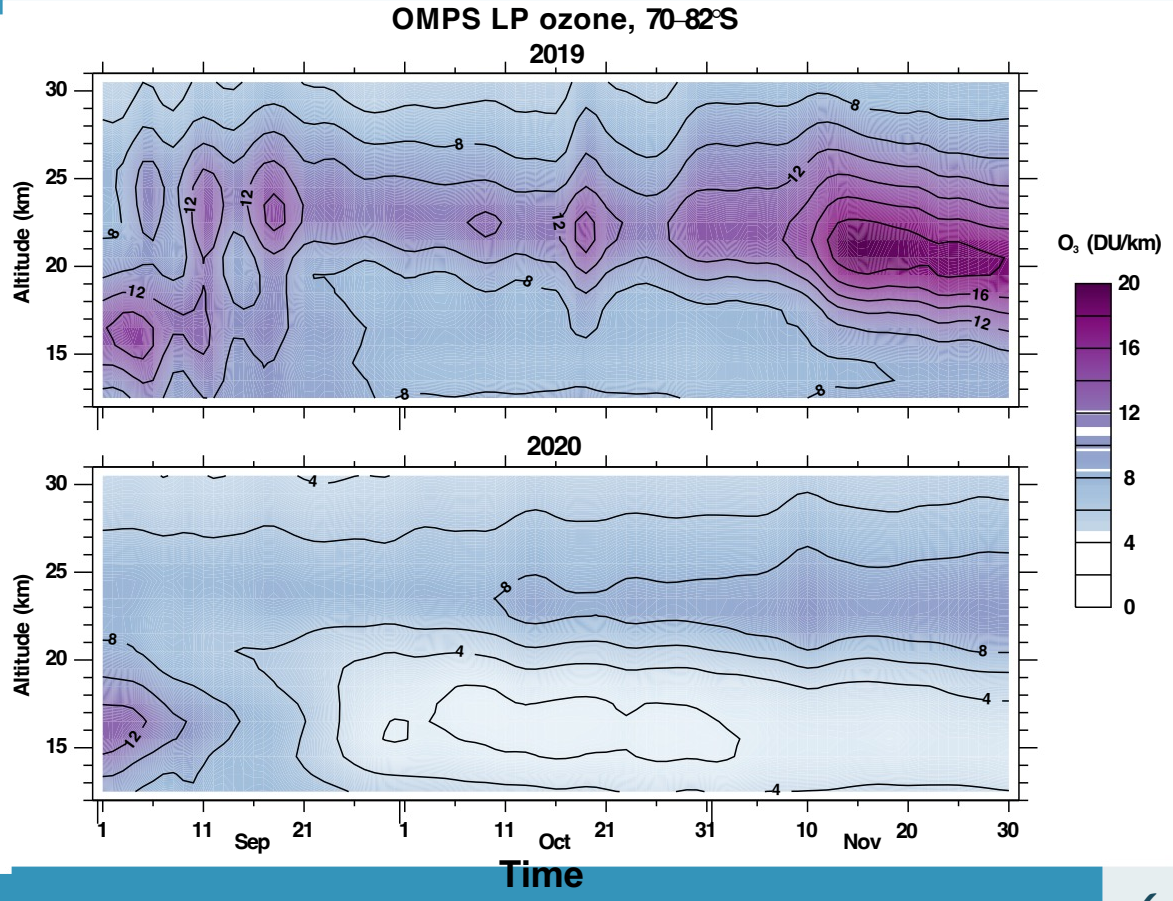


Total Ozone (DU)

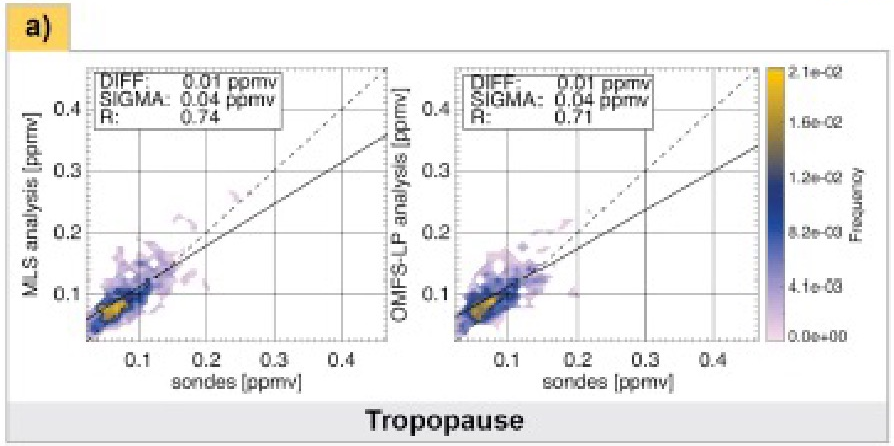
0 200 400 600

September 2020

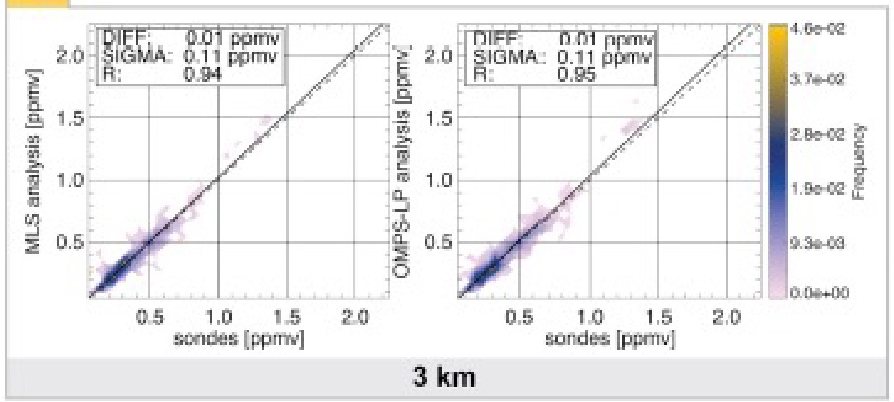




[Updated from Kramarova et al., 2014]



[Wargan et al., 2020]



- ✓ MLS and OMPS-LP assimilation experiments are in good agreement with independent data and with each other
- ✓ However, further work is needed to reduce a long-term spurious drift in OMPS-LP data

GODDARD EARTH SCIENCES

Natalya.a.Kramarova@nasa.gov